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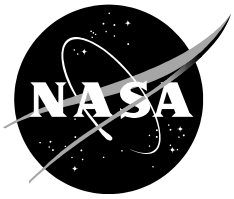

TESS Data Release Notes:
Sectors 1 – 13, Multi-sector Search, DR20

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These Data Release Notes provide information on the processing and export of data from the Transiting Exoplanet Survey Satellite (TESS). This data release is a combined, multi-sector transit search only. The underlying data products from individual observing sectors have been previously released. The data products included in this data release are the Data Validation (DV) reports, time series, and associated xml files for the threshold crossing events (TCEs) found by searching a combined data set including data from multiple observing sectors.

These data products were generated by the TESS Science Processing Operations Center (SPOC, Jenkins et al., 2016) at NASA Ames Research Center from data collected by the TESS instrument, which is managed by the TESS Payload Operations Center (POC) at Massachusetts Institute of Technology (MIT). The format and content of these data products are documented in the Science Data Products Description Document (SDPDD)[1]. The SPOC science algorithms are based heavily on those of the Kepler Mission science pipeline, and are described in the Kepler Data Processing Handbook (Jenkins, 2017)[2]. The Data Validation algorithms are documented in Twicken et al. (2018) and Li et al. (2019). The TESS Instrument Handbook (Vanderspek et al., 2018)[3] contains more information about the TESS instrument design, detector layout, data properties, and mission operations.

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This report is available in electronic form at
https://archive.stsci.edu/tess/

[1] https://archive.stsci.edu/missions/tess/doc/EXP-TESS-ARC-ICD-TM-0014.pdf
[2] https://archive.stsci.edu/kepler/manuals/KSCI-19081-002-KDPH.pdf
[3] https://archive.stsci.edu/missions/tess/doc/TESS_Instrument_Handbook_v0.1.pdf

1 Data

TESS Data Release 20 consists of results from a transiting planet search conducted with the combined data from Sectors 1 through 13. Figure 1 shows the Right Ascension (RA) and Declination (Dec) of all two-minute targets, color-coded by the number of sectors for which each target was observed. Targets with new data in any of Sectors 10–13 that were observed in multiple sectors were subjected to a multi-sector planet search (see Data Release 3, Data Release 6, Data Release 11, and Data Release 15 for Sector 1–2, Sector 1–3, Sector 1–6, and Sector 1–9 multi-sector planet searches, respectively). The data are the same 2-minute cotrended light curves presented in previous single sector data releases. Table 1 provides basic information and data release numbers for the observations of each sector. The observations span a 357 day period.

Table 2 summarizes the total number of targets with multi-sector data for this data release. A supplemental table[4] lists the targets searched, including a string indicating which sectors the target was observed in, whether the target produced a TCE or not, and whether the target completed DV analysis or not. Note that this information is presented only for targets in this data release, and does not show results for the cumulative distribution of targets with multi-sector data (i.e., the targets shown in Figure 1).

Table 1: Sectors Searched

Sector #	Physical Orbits	Start TJD[a]	End TJD	Data Release #
1	9,10	1325.293	1353.178	1
2	11,12	1354.101	1381.515	2
3	13,14	1385.897	1406.292	4
4	15,16	1410.900	1436.849	5
5	17,18	1437.826	1464.400	7
6	19,20	1468.270	1490.044	8
7	21,22	1491.626	1516.085	9
8	23,24	1517.342	1542.000	10
9	25,26	1543.216	1568.475	11
10	27,28	1569.432	1595.680	14
11	29,30	1596.772	1623.891	16
12	31,32	1624.950	1652.891	17
13	33,34	1653.915	1682.357	18

[a] TJD = TESS JD = JD - 2,457,000.0

[4] https://archive.stsci.edu/missions/tess/catalogs/targetinfo/tess_multisector_01_13_drn20_targetinfo_v01.txt

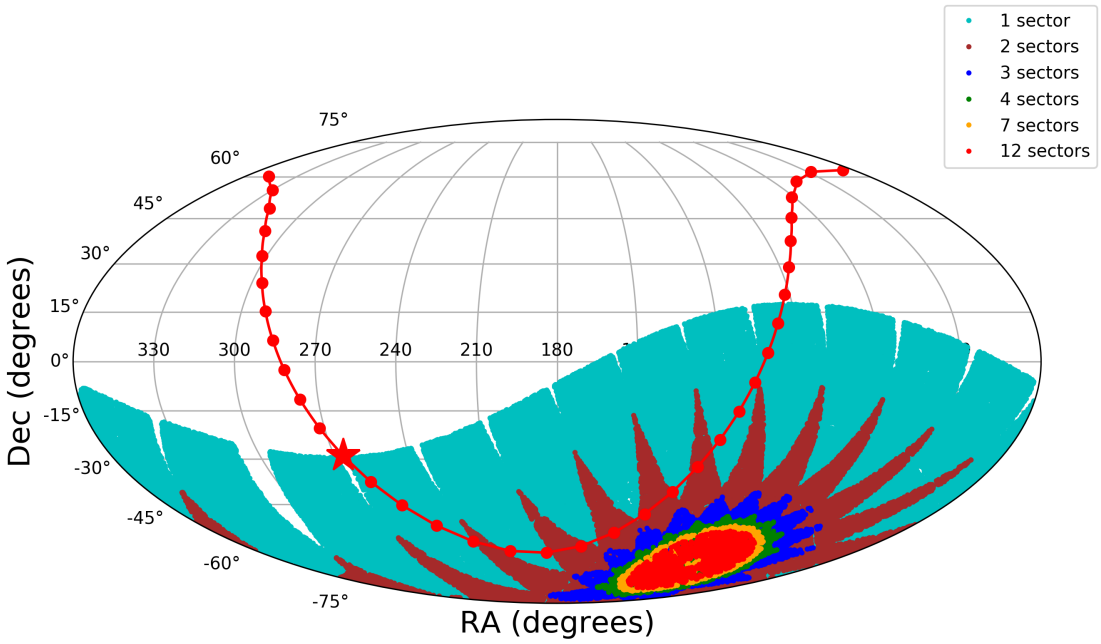

Figure 1: Right Ascension and Declination for all TESS two-minute targets, color-coded by the number of sectors in which that target was observed.

Table 2: Targets in this Data Release With Number of Sectors Observed

Number of Sectors	Target Count
2	7868
3	1959
4	750
5	808
6	738
7	602
8	504
9	902
10	853
11	1172
12	2156
13	1828

2 Transit Search and Data Validation

The light curves of 20,140 targets observed in Sectors 1 through 13 were subjected to the transit search in TPS. Figure 2 shows the 1-hour CDPP for the combined light curves of these targets. Threshold Crossing Events (TCEs) at the 7.1 σ level were generated for 3226 of these targets. A search for additional TCEs in potential multiple planet systems was conducted in DV through calls to TPS. A total of 5940 TCEs were identified in the SPOC pipeline on 3226 unique target stars. Table 3 provides a breakdown of the number of TCEs by target. Note that targets with large numbers of TCEs are likely to include false positives.

Figure 3 gives the distribution in period–transit depth space of the TCEs found in the multi-sector search. The top panel shows the distribution of orbital periods for the TCEs. After rapidly declining for periods out to 50 days, the distribution shows a broad tail towards the longest period allowed ($\lesssim$340 day) while requiring at least two transit events. Small excesses of TCEs at a given period can primarily be associated with scattered light, pointing jitter, or attitude tweaks (see below).

The vertical histogram in the right panel of Figure 3 shows the distribution of transit depths derived from limb-darkened transiting planet model fits for TCEs. The model transit depths range down to the order of 100 ppm, but the bulk of the transit depths are considerably larger.

Figure 4 shows the number of TCEs at a given cadence that exhibit a transit signal and highlights observing epochs with pointing and scattered light variations. Problematic epochs can be identified with the large ($>3\,\sigma$) peaks. The largest peaks are associated with thermal changes after the instrument anomaly in Sector 8 (see Data Release 10) and scattered light/glints near the attitude tweak in Sector 11 (see Data Release 16).

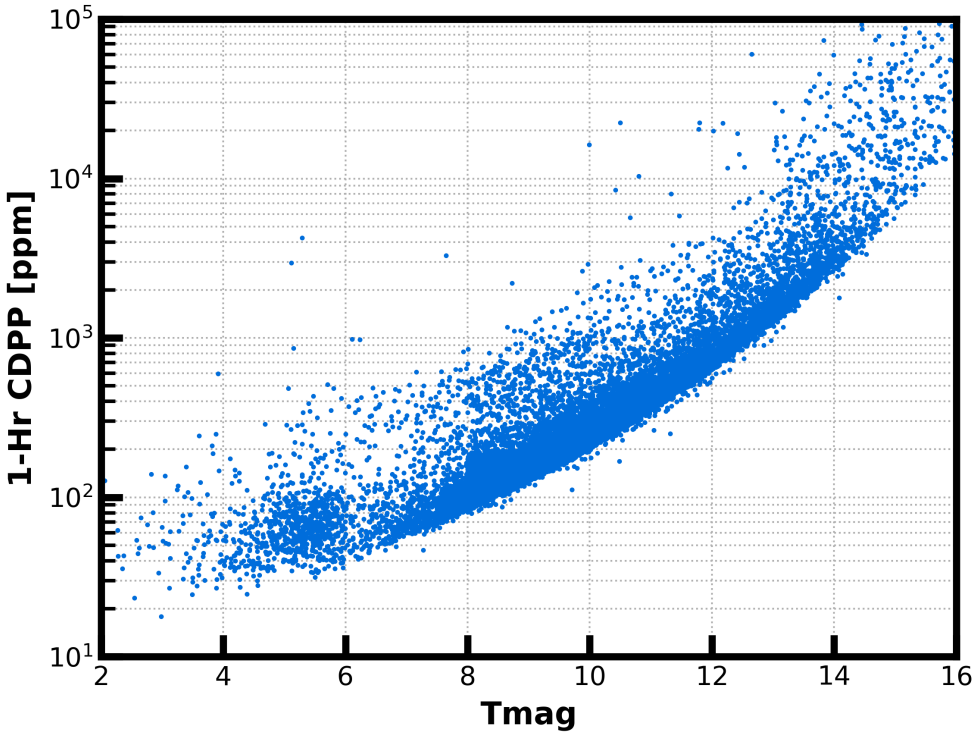

Figure 2: 1-hour CDPP. The points are RMS CDPP measurements for the 20,140 light curves from the Sectors 1 – 13 multi-sector search plotted as a function of TESS magnitude.

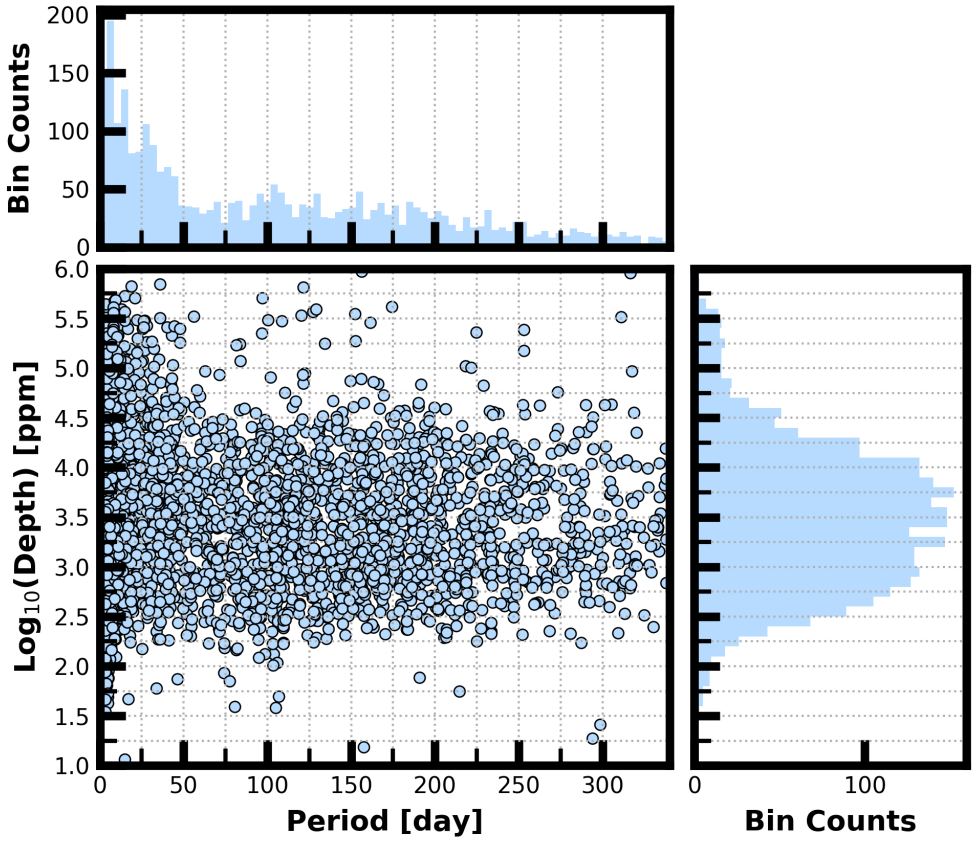

Figure 3: Lower Left Panel: Transit depth as a function of orbital period for the 5940 TCEs identified for the Sectors 1 – 13 multi-sector search. For enhanced visibility of long period detections, TCEs with orbital period <3.0 days are not shown. Reported depth comes from the DV limb darkened transit fit depth when available (or the DV trapezoid model fit depth if the limb darkened transit fit is not available). Top Panel: Orbital period distribution of the TCEs shown in the lower left panel. Right Panel: Transit depth distribution for the TCEs shown in the lower left panel.

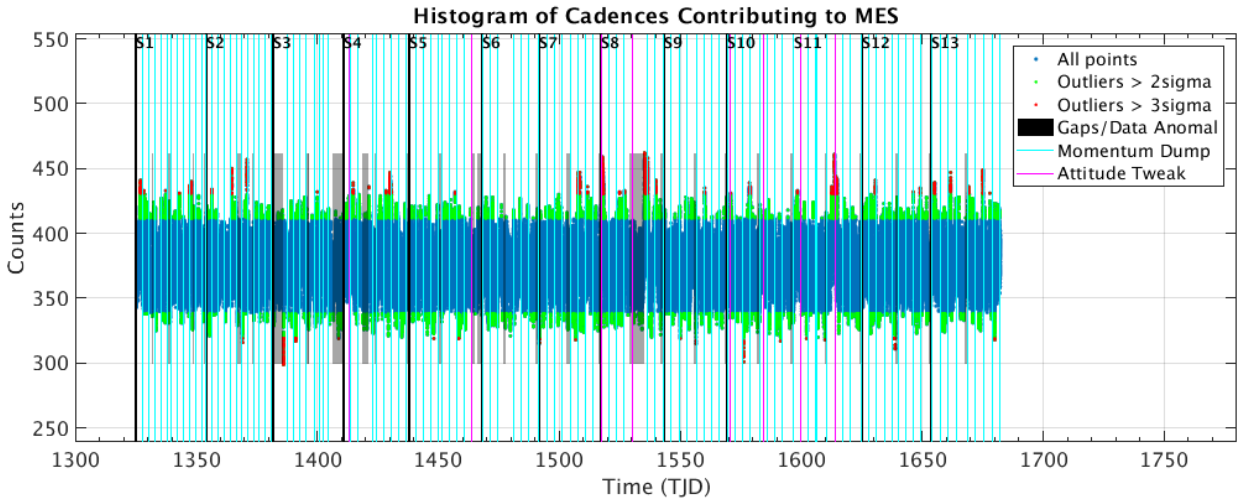

Figure 4: Number of TCEs at a given cadence exhibiting a transit signal. Isolated peaks are caused by a single event and result in spurious TCEs. The peaks typically align with pointing instabilities and strong background variations. TCE ephemerides are projected back to the start of Sector 1 even if the associated targets were not observed that early in the mission.

Table 3: Sector 1 – 13 TCE Numbers

Number of TCEs	Number of Targets	Total TCEs
1	1669	1669
2	870	1740
3	370	1110
4	200	800
5	81	405
6	36	216
–	3226	5940

References

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Acronyms and Abbreviation List

BTJD Barycentric-corrected TESS Julian Date

CDPP Combined Differential Photometric Precision

Dec Declination

DV Data Validation Pipeline Module

KDPH Kepler Data Processing Handbook

MAST Mikulski Archive for Space Telescopes

MES Multiple Event Statistic

NAN Numerical Not-A-Number

POC Payload Operations Center

ppm Parts-per-million

RA Right Ascension

RMS Root Mean Square

SDPDD Science Data Product Description Document

SNR Signal-to-Noise Ratio

SPOC Science Processing Operations Center

TCE Threshold Crossing Event

TESS Transiting Exoplanet Survey Satellite

TIC TESS Input Catalog

TIH TESS Instrument Handbook

TJD TESS Julian Date

TOI TESS Object of Interest

TPS Transiting Planet Search Pipeline Module

UTC Coordinated Universal Time

XML Extensible Markup Language